DAMASKINOS: The Prototype Corpus of Greek Orthodox Ecclesiastical Chant Voices

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Abstract. This work describes the design and implementation of the DAMASKINOS chanting voices corpus that includes a representative number of Greek Orthodox Ecclesiastical Music (GOEM) styles. The essential characteristic of DAMASKINOS is the fact that it is not based on preexisting chanting performances or on recordings under nonidentical conditions. What makes this collection unique is that DAMASKINOS relies on rigorous design requirements and strict implementation specifications. Following specific criteria, twenty famous professional psaltes (chanters) from different parts of Greece were selected. They were invited to chant the same set of selected Byzantine troparia (hymns) of papadikon, sticherarikon and heirmologikon melodic forms in all the eight modes of GOEM. Their voices were digitally recorded under the same well-controlled conditions. Both the sound-pressure (microphonic) and the synchronized ElectroGlottoGraphic (EGG) signals were captured and digitized. Moreover, the recordings include: a) chanting of exercises in GOEM scales in each Byzantine mode and b) reading-aloud the texts of chanted hymns (i.e. a type of ecclesiastical speech). In some cases the recordings include aerophone measurements in order to collect additional information, such as subglottic pressure and glottal airflow. By applying a semi-automatic methodology, the recorded signals of the DAMASKINOS corpus were synchronized with additional tagging meta-data in five levels: a) musical syllable boundaries, b) characters of musical notation, c) notation-based (expected) pitch, d) real (performed) pitch and e) transcription of chanted voice. In the paper we describe: the methodology followed in designing and developing the DAMASKINOS corpus, the protocols applied, the experimental setup and the approach for data acquisition and tagging. We intend DAMASKINOS to constitute a prototype corpus of GOEM voices that will serve the international scientific community towards the accomplishment of advanced acoustic and musicological research of GOEMs' various characteristics, as well as comparative studies with other singing voice styles, chanting or not.

1. Introduction

The Greek Orthodox Ecclesiastical Music (GOEM) or Byzantine Ecclesiastical Music or Byzantine Chant (BC), as otherwise it is called, concerns the liturgical music of the Greek Orthodox Church. It is a purely monophonic music performed by chanters called psaltes (singular: psaltis). With no doubt the GOEM is an important part of Greek cultural and religious heritage. Thus the systematic and thorough study of GOEM under various academic disciplines is very important and valuable. It should be noted that up to now most of the Byzantine Ecclesiastical Music studies in the field of musicology are referred to the sub-discipline of historical musicology (paleography, hymnography, musical

analysis and biography of composers) as the main field of research[1]. Unlike, some sub-disciplines, such as music theory, analysis and composition, have been less studied, while others, such as performance practice and research or music psychology, cognition and therapy, have not been investigated at all. Recently some studies on the acoustic analysis of GEOM,[2] both in the domains of performance practice and music theory, or GOEM synthesis[3] have been presented.

The term "corpus" refers here to a collection of audio recordings with appropriate annotation, meta-data and the corresponding documentation. For the acoustic analysis research in a specific domain of voice the most desirable option is to have available a corpus, as defined above, that has been collected systematically in the past and has been used by other researchers. In that case, on one hand it provides a place to start and, on the other hand and most important, it constitutes a reference to compare the research results between different research teams. Corpus based approaches are very popular in the domain of speech[4] and recently in the domain of singing.[5] But, searching the scientific literature we have not found any corpora for GOEM or BC. Thus, it is obvious that there is a need for designing and implementation of a GOEM corpus to include the basic but essential information of BC, in other words, both the selected Byzantine troparia (hymns) and psaltes should summarize, if possible, the main features of the Byzantine singing style. This paper presents the DAMASKINOS reliable annotated corpus of GOEM recordings. In our design of DAMASKINOS we intend to develop a prototype corpus of BC voices that will serve the international scientific community towards the accomplishment of advanced acoustic and musicological research of GOEMs' various characteristics, as well as comparative studies with other singing voice styles, chanting or not. In the next paragraphs we describe the design and development methodology for the DAMASKINOS corpus as well as the applied protocols, the experimental setup and the approach for data acquisition and tagging. The term "tagging" refers here to a procedure by which we add on the acoustic signal a number of descriptive tags and coded information values. The tagging metadata are essential for searching more easily and accurately specific information within a recording.

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[1] Diane Touliatos-Miles, "The status of Byzantine Music through the twenty-first century", in *Byzantium: Identity, Image, Influence*, ed. Karsten Fledelius (Copenhagen: The University of Copenhagen, 1996), 449-463.

[2] Dimitrios Delviniotis, "A classification of Byzantine singing voices", *Proceedings of EUSIPCO-98* (Rhodes, 1998), 129-132. Dimitrios Delviniotis, Georgios Kouroupetroglou, and Sergios Theodoridis, "Acoustic Analysis of musical intervals in modern Byzantine Chant Scales", *Journal of the Acoustical Society of America (JASA)* 124/4 (2008), EL262-EL269. Δημήτριος Δελβινιώτης και Γεώργιος Κουρουπέτρογλου, "Ακουστική ανάλυση της μουσικής και μη απαγγελίας των φωνηέντων ψαλτικών φωνών", *Πρακτικά Δ΄ Διεθνούς Μουσικολογικού και Ψαλτικού Συνεδρίου* (Αθήνα, 2009). K. Tsiappoutas, G. Ioup, and J. Ioup, "Measurement and analysis of Byzantine chant frequencies and frequency intervals", *JASA* 116 (2004), 2581.

[3] I. Zannos, A. Georgaki, D. Delviniotis, and G. Kouroupetroglou, "Real-time control of Greek Chant Synthesis", *Proceedings of the 3rd International Conference Sound and Music Computing - SMC06* (Marseille, 2006), 47-52.

[4] Linguistic Data Consortium http://www.ldc.openn.edu (accessed on Nov. 5th 2011).
ELRA: European Language Resources Association http://www.elra.info/ (accessed on Nov. 5th 2011).

[5] AIRS: Advancing Interdisciplinary Research in Singing http://www.airsplace.ca/ (accessed on Nov. 5th 2011).

2. Design and development methodology

The modern Byzantine Chant (BC) traditionally is chanted either by choir or by one psaltis usually supported by the ison, i.e. the sole vocal accompaniment of BC. In the last decades there has been a tendency to have almost exclusively choral performance of Byzantine melodies, thus creating the impression that this is the only appropriate way of BC performance. At the same time, all the richness of micro-melodies existing in the sole (monodical) performance remains hidden and lost inside the choir. Moreover, as the old BC teachers reported,[6] there were differences in music style and performance among various psaltes anytime BC was chanted by a single psaltis, thereby establishing "schools" of music performance. Each chanting style is characterized among others by vocal and melodic features being transferred in some way from the teacher to the student. Thus, during the design of the DAMASKINOS corpus our aim was to include the main styles of the modern Byzantine chanting.

We know that the singing voice shows explicit differences compared to the speech.[7] Furthermore, there are differences between various musical genres. In the same way a voice of one person performing BC appears to be different with his voice in normal speech or with his voice performing western opera.[8] More specifically, an alteration in the voice quality exists between the two ways of voice usage which can be measured through acoustic analysis. Thus, in designing the DAMASKINOS corpus the reading aloud of the texts has been included. We have to notice that there are various ways of reading the Byzantine hymns[9] which also should be recorded in detail.

2.1. Selection of Participants

Although the elements distinguishing a BC style from another are not known until now, a skilled listener can recognize that a) a particular psaltis is chanting differently from other psaltes and b) he is chanting according to a certain BC style. From our experience (as the first of the authors has been psaltis for many years) a special feature of a BC style could be related to the "type" of psaltis's voice according to the dissertation of Delviniotis.[10] In that study the formant characteristics of several BC voices were studied. One of the findings was that the frequencies of the higher formants significantly varied from one psaltis to another. At the same time, the chanting voices could be grouped into a number of classes based on the frequencies of the higher formants (**Fig. 1**). However an open question still exists regarding the relation between the classes and styles: Do psaltes pertaining to a certain voice class also belong to a particular Byzantine chanting style? By considering that the answer could be positive (in fact our observations confirm that), an important criterion was introduced for selection of a single psaltis in order to participate in DAMASKINOS: the specific class of the chanter's voice. In order to achieve a better discrimination, in this work we have grouped the chanting voices into four

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[6]Φίλιππος Οικονόμου, *Βυζαντινή Εκκλησιαστική Μουσική και Ψαλμωδία*, Τόμος Α´ (Αίγιο, 1992), 235-245.

[7]Johan Sundberg, *The Science of the Singing Voice* (Northern Illinois University Press, 1989).

[8]Δημήτριος Δελβινιώτης, "Σχέση φωνηέντων οπερατικού τραγουδιού – Βυζαντινού μέλους και Ελληνικής ομιλίας", *Α´ Διεθνές Συνέδριο Βυζαντινής Μουσικής* (Πανεπιστήμιο Μακεδονίας, 2003).

[9]Athanasios Vourlis, *The reading and pronunciation of scriptural texts* (in Greek) (University of Athens, 2004), 1-172.

[10]Dimitrios Delviniotis, *Analysis of Byzantine Chant via Signal Processing Techniques,* PhD, Department of Informatics and Telecommunications (University of Athens, 2002).

classes. We have selected five participants for each class, namely, 20 in total. Other criteria for the selection of a particular psaltis were: a) the chanter's age, b) his artistic excellence, c) his health status, d) his recording and writing activity, e) the teacher(s) of the psaltis in BC. Finally each candidate psaltis was interviewed before the final selection. Participants were selected to be between 40 and 70 years old, because in this period of age they are considered to be artistically more mature. The selection concerning the voice was based on that its style retains the characteristics of an artistic voice. The artistic experience of a psaltis as well as his musical knowledge (education), his music perception and his trained voice are parts of his artistic excellence. Since one of the purposes of the DAMASKINOS corpus's creation was to serve as a comparison between two genres of vocal music, BC and opera, the participation of opera singers was necessary for the relative acoustical analysis. Two participants were selected to be both psaltes and opera singers (tenors) while their voices pertain to one of the above four classes. Although the selected opera singers were only two, the change in the acoustical parameters could be detected while a psaltis tries to chant the BC troparia like in opera. Also, we notice that the two selected singers were tenors and they chanted almost in the same pitch range in which all psaltes usually chant.
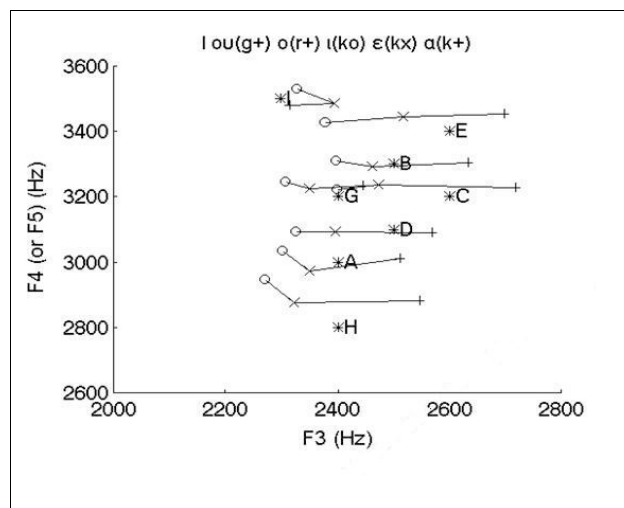

Figure 1. Correlogram between F3 and F4 (or F5) formant frequencies for Byzantine Chant voices grouped into 8 classes. The symbols 'o, x, +' correspond to the vowels /i, e, a/, respectively, while the asterisk corresponds to the average value of the three vowels.

Each candidate psaltis was informed about the scope of the experiment, the content of the repertory to be chanted and the recording's process. In the case a candidate expressed interest and willingness to participate, we continued to the next stage of the interview which included questions about his biography concerning the BC art, namely, the age, the place of birth, the state of health, the artistic activity, the recording and writing activity, the place of living, the teachers and the artists who influenced him, the views about his voice, his own artistic BC style as well as the BC in general.

The initial selection of a psaltis as a candidate for participation was based on his public recordings from which a part was acoustically analyzed in order his voice to be classified

in one of the four classes mentioned before. The answers of a particular psaltis to the interview's questions have been investigated regarding his BC style or the BC "school" he belongs to. Also, his view about issues in BC, such as for the special reading of the musical notation characters (black and red signs) or the music performance, are important for future research concerning the possible ways of interpretation of the BC's musical texts. For both designing purposes and checking the analysis's results one of the selected psaltes was the first author of this study. An effort was made to have psaltes from all the main parts of the Orthodox Greek Church. Thus there were psaltes from Athens, Crete, Epirus, Macedonia, Thessaly, Central Greece, Aegean Islands, Constantinople and Holy Mountain. **Table 1** presents the list of the participants in the DAMASKINOS corpus.

Psaltes:
> fr. Antypas Agioritis
> Ioannis Arvanitis
> Achilleas Chaldaiakis
> Ioannis Chasanidis
> Georgios Chatzichronoglou
> Charis Daravanoglou
> Grigorios Daravanoglou
> Panagiotis Kalambakas
> Fotios Ketsetzis
> Evangelos Menegas
> Dimitrios Neratzis
> Antonios Plaitis
> Theodoros Vasileiou
> Athanasios Voujouklis
> Athanasios Vourlis
> Spyridon Yfantis
> fr. Panagiotis Ioakeim (*partial participation*)

Psaltes–Tenors:
> Ioannis Christopoulos
> fr. Petros Pantazis

Psaltis for experimentation:
> Dimitrios Delviniotis

Table 1. Participants in the DAMASKINOS corpus.

2.2. Selection of Byzantine Chant hymns and exercises

The main purpose of the DAMASKINOS corpus was to include the greatest possible variety of musical features for BC. Moreover it was important to include all the possible combinations of the Greek phonemes. The selected Byzantine hymns involved most of the types of Byzantine "troparia", as the chanted hymns are called, namely: stichera, doxastika, cherouvika, polyeleoi, kekragaria, pasapnoaria, heirmoi of canons, arges (slow) katavasies and leitourgika. The stichera, doxastika, heirmoi of canons and arges katavasies were chanted in their own BC mode. For example, the sticheron "Κυκλώσατε

λαοὶ Σιών” was chanted in the first mode, while the sticheron “Τοῦ ξύλου τῆς παρακοῆς” in the fourth mode. The pasapnoaria, kegragaria and cherouvika were chanted in all eight modes. Within all stichera there are represented all eight modes, as well as for each of the following: doxastika, heirmoi of canons and arges katavasies. However, the corpus would be insufficient if the three “chroes” were not included, namely “spathi”, “kliton” and “zygos”, which are embedded in the music of troparia of “polyeleoi”. Those correspond to specific ways of chanting that resemble to the “modes” of BC and are called “chroes”. According to Chrysanthos of Madytos, the troparia are categorized by the number of notes corresponding to one text syllable in four melodic forms: the heirmologic melody, the “new” sticheraric melody, the old sticheraric melody and the papadic melody. Thus, the selected troparia for the DAMASKINOS corpus concern all the types of melodies, except the old sticheraric one. We have to notice that although the etymology of the words “heirmologic” and “sticheraric” regarding the melodies, comes from the names of the corresponding hymns, called heirmoi and stichera respectively, these terms are not used close to the original meaning. Therefore, in the modern manuals of BC these melodic forms are referred by considering that in the case of the heirmologic melody one note corresponds to one syllable, in the new sticheraric melody more than one note corresponds to one syllable and for the two last types of melodies many notes correspond to one syllable.[11]

Book	Composer
Εἱρμολόγιον / Heirmologion	Ἰωάννης Πρωτοψάλτης / Ioannis Protopsaltis
Ἀναστασιματάριον / Anastasimatarion	Ἰωάννης Πρωτοψάλτης / Ioannis Protopsaltis
Ἀναστασιματάριον / Anastasimatarion	Κωνσταντῖνος Πρίγγος / Konstantinos Pringos
Εἱρμολόγιον / Heirmologion	Πέτρος Πρωτοψάλτης Βυζάντιος / Petros Protopsaltis Byzantios
Μουσικὴ Κυψέλη / Mousiki Kypseli	Στεφάνος Λαμπαδάριος / Stefanos Lambadarios
Μουσικὴ Συλλογή Γεωργίου Πρωγάκη: Χερουβικά / Musical Collection of Georgios Progakis: Cherouvika	Πέτρος Λαμπαδάριος & Γρηγόριος Πρωτοψάλτης / Petros Lambadarios & Gregorios Protopsaltis
Μουσικός Πανδέκτης: Πολυέλεοι / Mousikos Pandektis: Polyeleoi	Χουρμούζιος Χαρτοφύλαξ / Chourmouzios Chartofylax

Table 2. Byzantine chanting books and the composers (in Greek and English) from which the musical texts were extracted for the DAMASKINOS corpus.

Since each melody has its own features, the inclusion of troparia of all three melodic types creates an adequate database for modern BC. According to Georgios Chatzitheodorou[12] there are totally eight subdivisions of these four melodic types: the

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[11]D. Panagiotopoulos, *Theory and Praxis of Ecclesiastical Byzantine Music*, 5th ed. (in Greek) (Athens: Soter Press, 1991).

[12]Γ. Χατζηθεοδώρου, *Θεωρητικόν Βυζαντινῆς Μουσικῆς –Μέρος Δεύτερον – Θεωρητικόν* (Κρήτη: Εκδόσεις Πολυχρονάκης, 2004).

concise syllabic heirmologic, the slow heirmologic, the "new" concise sticheraric, the "new" slow sticheraric, the old sticheraric, the papadic, the kalophonic heirmologic and the ekphonetic melodies. Among all these subdivisions, the old sticheraric and the kalophonic heirmologic have not being included in the corpus because of their rare usage in the contemporary practice. Regarding the ekphonetic melody this will be described in the next paragraphs. The musical texts were selected from the "classical" compositions of the Patriarchal Psaltes made after the reform of the BC musical notation. This is a neumatic simplification system of the old Byzantine musical symbols after the early 19th century. All the selected texts (**Table 2**) were extracted from the BC books written by Patriarchal teachers and psaltes and are representative of the Patriarchal style of composition and for this reason we consider them as "classical".

Psaltes were recommended to perform the BC hymns by interpreting both the qualitative and quantitative BC characters (semadia "σημάδια", as they are called otherwise) of the musical text, but with their own personal style of chanting. In order to achieve high performance, the frequency range of the BC composition should match with the pitch range of the psaltis, by taking the full advantage of his vocal capabilities. Thus, for purposes of convenience and better artistic performance, each participant chose the height of notes appropriate to his voice. Also, performers were recommended to chant with moderate vocal intensity and without enforcing the voice either by shouting or by whispering.

Troparia Types	Melody
Stichera	"new" sticheraric
Doxastika	"new " slow sticheraric
Heirmoi of canons	concise syllabic heirmologic
Arges katavasies	slow heirmologic
Cherouvika	papadic
Kekragaria	"new" slow sticheraric
Pasapnoaria	"new" slow sticheraric
Leitourgika	papadic
Polyeleoi	papadic

Table 3. Types of troparia chanted and read aloud recorded in the DAMASKINOS corpus with their corresponding melodies.

Within the Divine Liturgy some hymns are spoken (read aloud) with a special way of speaking which we characterize as "ecclesiastical speech", in contrast to the normal "speech". This way of speaking in the Church is a kind of ekphonetic type of melody. Also, another ekphonetic type concerns the text of "Apostolos", namely the epistle of Apostle Paul. The reading aloud of the Apostolos is a mixture of both spoken and chanted (speech with melody) voice, namely this is spoken chant or chanted speech. The

main feature of the "Apostolos" is the lack of a certain tempo, though there is a movement in a particular musical scale. In general, the "Apostolos" is not chanted with the same style as other spoken hymns. For example the "Πάτερ ἡμῶν" is rather spoken than chanted, namely resembles more to speech than chant. Both the ecclesiastical speech and "Apostolos" were included in the corpus to the direction of a broader understanding of the vocal nature of BC which ranges from the spoken voice up to chanted voice. Therefore, in order to investigate the relation between speech and BC, all the texts of hymns were spoken soon after they were chanted, for purposes of a direct comparison between them.

For the two psaltes who were also opera singers there was an additional hymn – the sacred aria composed by Alessandro Stradella or Louis Niedermeyer[13] entitled "Pieta, Signore". All the troparia chanted by these two singers should be sung in a way of singing as in opera, namely in a way they used to.

In addition to troparia, psaltes were asked to chant one musical scale for each of the five vowels /a, e, i, o, u/, for all the Byzantine music genera: diatonic, malakon (soft) chromatic, skliron (hard) chromatic and enharmonic ones. More specifically, the whole scale was chanted with the same vowel for all the eight notes of the scale, in the two opposite directions: ascending and descending order. Particularly, for the diatonic genus, the range of the scale was extended over about one octave while the whole range was depending on the vocal capability of the performer. The purpose of this exercise was to acquire information regarding the vocal range of the performer. We have asked each participant to chant the scales in a convenient way for him. That means that although he ought to chant the ascending and descending scales one after the other, he could prefer to chant a part of the scale (that is a tetrachord) and then the rest of the scale but in ascending and descending form again. Explaining more that way, the performer should have in mind the musical intervals of a certain genus recalling them with one of the following ways: a) by remembering one BC mode pertaining to that genus, b) mentally chanting either tetrachords of scale, as for the first diatonic mode, or trichords of scale, as for the second malakon chromatic mode, and c) the personal way he preferred to use. Since the term genus refers to an abstract concept of a family of BC modes (for example, the modes belonging to malakon diatonic genus) and not to a specific BC mode, the measurements for a genus could not be made on a BC mode. Conversely, by performing measurements on the musical scales it is possible to control the size of the musical intervals and to deteriorate the attraction effect through which the position of the notes inside a scale is affected by various psychological factors such as the "intra-genera interaction"[14] or the attraction to the target note.[15] The problem with the performance of musical scales has to do with the movement of notes towards the target note that exists in mind. For example, if a BC scale is performed in the form of a pentachord and a tetrachord in succession, then the fourth note of the pentachord would tend to get closer to its highest note, while if the scale is performed in the form of two tetrachords separated by a tone (a major second), the fourth note of the low tetrachord would not be changed at all. Taken into account that in a descending scale

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[13]David Mason Greene, *Biographical encyclopedia of composers*, edited by A. M. Petrak (The Reproducing Piano Roll Foundation, 2007), 1547.

[14]See Delviniotis, Kouroupetroglou, and Theodoridis.

[15]See Tsiappoutas, Ioup, and Ioup.

there is the tendency to lower the above fourth note of the pentachord[16] it is sensible to say that the position of this fourth note is balanced between the two directions of the scale. Provided that all psaltes chanted a cappella, namely without instrumental accompaniment, it is obvious that any chanted note was recalled from the human memory and therefore some randomness of the note's position within the scale would be unavoidable.

Another type of measurements comprised those regarding the aerodynamic parameters of the psaltis's voice. These measurements were made using an aerophone equipment[17] and by asking each participant to have a recitation of a sequence of three syllables: "pi-pi-pi" at two levels of volume: normal (as in normal speech) and high (with maximum intensity), as well as in a sequence of seven complex tones: G2, C3, E3, G3, C4, E4, C2 (with organ simulation), of 3 seconds duration. Each tone was preceded by a similar tone of C3 and the total sequence of tones: C3-C3-G2-C3-E3-C3-G3-C3-C4-C3-E4-C3-C2, presented to the psaltis via headphones, while he wore the mask of the aerophone (**Fig. 2**) and sung the sequence "pi-pi-pi" in the tone he had heard after the previous C3 tone. This connective tone was used for reference to the next tone and also to give time to the psaltis in singing the next tone. Those measurements concerned air flow and subglottal pressure ones which are related to the function of the voice. We know that the glottal resistance, the aerodynamic

(a)   (b)

Figure 2. The Aerophone II apparatus (a) and its usage for the aerodynamic measurements of the voice (b).

input power, the acoustic output power of glottis and the glottal efficiency could be estimated by an analysis of the aerophone signals (**Fig. 3**). The pitch range of over two octaves described above was designed in order to examine the changes of the voice of psaltes in connection with its acoustical parameters.

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[16]See Delviniotis, Kouroupetroglou, and Theodoridis.
[17]F-J Electronics. In http://www.f-jelectronics.dk (accessed on November 5th, 2011).

Over the last decades the electroglottogram (EGG) has been an important and reliable technique for describing laryngeal activity at the vocal fold level and quantifying and objectively comparing similarities and differences.[18] EGG in combination with the acoustic analysis of the sound pressure signal could give useful information regarding voice parameters, the study of which could lead to a better understanding of BC voice. The electroglottogram (EGG) of each participant during the chanting was recorded through two electrodes placed on the thyroid cartilage of the psaltis, namely on either side of the larynx, with an impedance collar strapped around the neck that shows time-varying contact area for the vocal folds (**Fig. 4**).
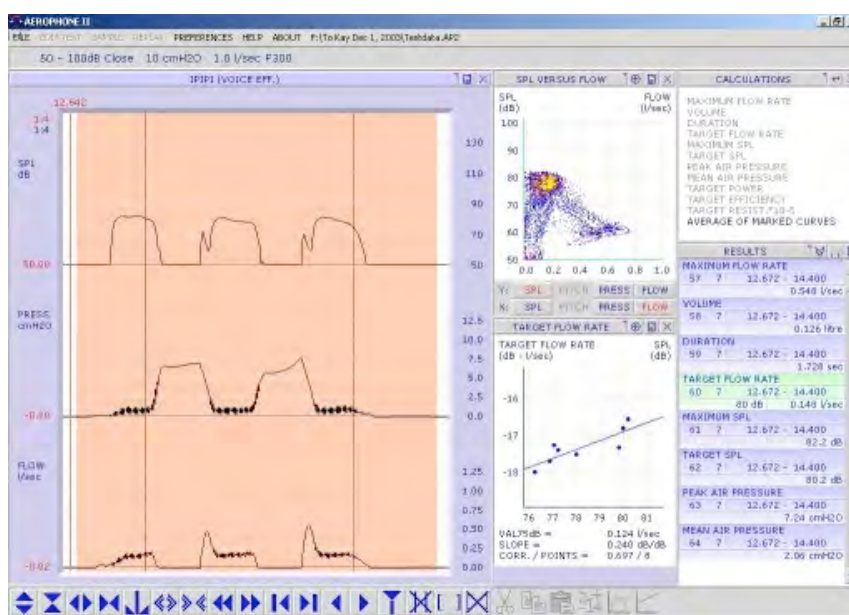

Figure 3. Sound pressure level (SPL), subglottal pressure and glottal flow analysis with Aerophone II.

3. Experimental setup and Data collection

The recording process for the DAMASKINOS corpus started in July 2005 and was completed in July 2006. The recordings took place in an appropriate acoustic studio using the professional portable console AW16G of YAMAHA and the data were recorded directly by the built-in hard disk drive.

The voice pressure signal was captured through a K2 RODE condenser microphone (**Fig. 4**) as the first channel and EGG signal was recorded by Glottal Enterprises as the second channel (**Fig. 5**). For the aerodynamic measurements we have used the Aerophone II apparatus of F-J Electronics.[19]

The signals from the microphone and the EEG were sampled at 44,1 kHz, 16 bits. For all the recordings the level of console preamplifiers was kept stable to ensure that the experimental conditions remained unchanged for a valid comparison among psaltes. All

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[18]Electroglottography: in http://aune.lpl.univ-aix.fr/~ghio/pedago-EggUK.htm (accessed on November 5th, 2011).

[19]See ref. (21).

psaltes were asked to chant in normal voice intensity for all performed melodies except for some exercises which will be reported in the sequel. The reason for normal volume of voice was that the voice should not be forced beyond its capabilities.

Figure 4. Experimental setup showing a participant with the microphone, the electroglottographic sensors and the headphones during the recordings.
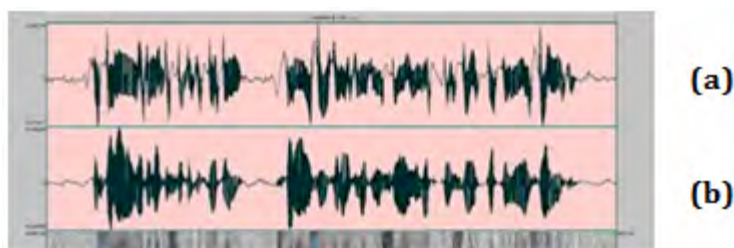

Figure 5. Synchronized signals from the electroglottogram (EGG)(a) and the sound pressure (b).

The audio material was edited through a common software editor by cutting and rejecting all the parts not containing the Byzantine hymns or the exercises. Moreover, other unwanted parts such as clicks, cough, and duplication, were removed through detailed editing. The recordings for each participant have a duration of four hours. The final clear material was stored in DVDs one for each psaltis organized in ten long wav files entitled: 1) anagnosi, 2) apostolos, 3) argoeirmo, 4) cherouvika, 5) doxastika, 6) eirmo, 7) polyeleoi, 8) scalesaeroph, 9) stichera and, 10) stichologia. The "argoeirmo" file contains the arges katavasies, the "eirmo" includes the "heirmi of canons", the file "anagnosi" contains all the reading texts, while the file of "stichologia" contains all the chanted lyrics just before the stichera but included in the file of "stichera". For the psaltes who were opera singers there was an additional file of "aria" containing the aria described above.

A tagging process has been applied to the audio material and consists from both a set of descriptive tags and coded information values, corresponding to a particular segment of recording.[20] The tagging process annotates the corpus through the PRAAT program[21] in five layers: 1) lyrics, 2) BC notation, 3) music intervals, 4) score describing the performance and 5) the performed music intervals. In such a way, the material was annotated with metadata at five levels which are described as follows: a) The time-boundaries for each syllable of the lyrics BC text. These boundaries are placed manually and determine the duration of syllables that are annotated. b) The musical characters of the Byzantine musical notation in each syllable. c) The notation-based expected pitch (the exact difference was calculated based on the BC scales). d) The actual (performance-based) music characters of the Byzantine Notation. e) The real-perceptual pitch.
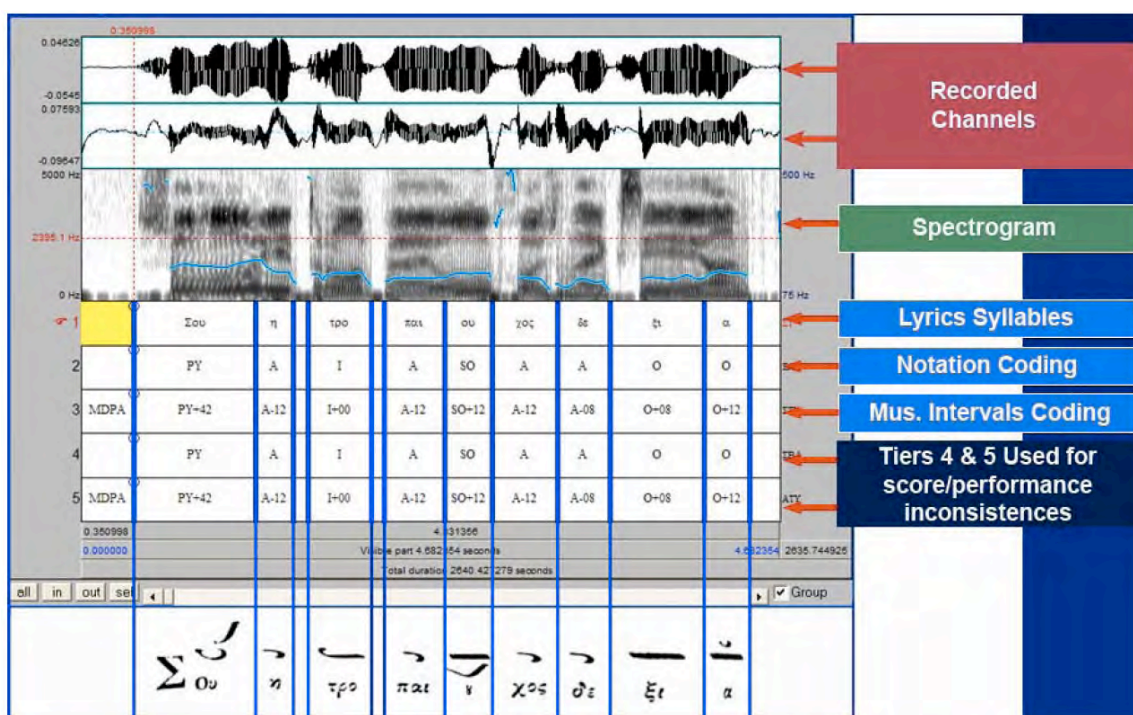

Figure 6. The five layers of the tagging process synchronized with the recordings from the EGG and the microphone along with Spectrogram of the voice.

4. Conclusions

We have described the design and development of the DAMASKINOS corpus: a prototype annotated collection of Byzantine Chant hymns both chanted and read-aloud, based on a total of twenty psaltes from all over Greece. DAMASKINOS includes on one hand the main musical styles of BC and on the other the most representative BC types of

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[20]Georgios Chryssochoidis, Dimitrios Delviniotis, and Georgios Kouroupetroglou, "A semi-automated tagging methodology for Orthodox Ecclesiastic Chant Acoustic corpora", in *Proceedings of the 4th Sound and Music Conference - SMC07* (Lefkada, Greece, 2007), 126-133.

[21]Paul Boersma and David Weenink, *Praat: doing phonetics by computer*. Version 5.3.03, http://www/praat.prg (accessed on 16th November 2011).

voices. It intends to serve the researchers in studying many musical and acoustical characteristics of BC. It aims to become a basis for further advanced acoustic, musicological and interdisciplinary, as well as comparative scientific research on the GOEM.

5. Acknowledgments